



US009124050B2

(12) **United States Patent**
Siebens

(10) **Patent No.:** **US 9,124,050 B2**
(45) **Date of Patent:** **Sep. 1, 2015**

(54) **ELECTRICAL CONNECTOR HAVING
GROUNDING MECHANISM**

H01R 24/20 (2013.01); *H01R 2101/00*
(2013.01); *H02B 13/0358* (2013.01); *H02B*
13/075 (2013.01)

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(58) **Field of Classification Search**
CPC *H01R 13/53*; *H01R 13/6485*; *H01R*
13/6666; *H01R 13/703*; *H01R 23/6873*;
H01R 13/7036

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USPC 439/181, 187, 921
See application file for complete search history.

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 110 days.

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(21) Appl. No.: **13/943,920**

(22) Filed: **Jul. 17, 2013**

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(65) **Prior Publication Data**

US 2014/0024241 A1 Jan. 23, 2014

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Related U.S. Application Data

(60) Provisional application No. 61/673,469, filed on Jul.
19, 2012.

(51) **Int. Cl.**

H01R 13/53 (2006.01)
H01R 24/66 (2011.01)
H01R 11/15 (2006.01)
H01R 13/207 (2006.01)
H01R 4/56 (2006.01)
H01R 13/447 (2006.01)
H01R 13/648 (2006.01)
H01R 24/20 (2011.01)

(Continued)

(52) **U.S. Cl.**

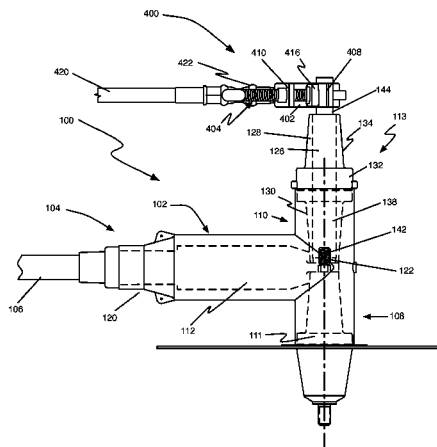
CPC *H01R 24/66* (2013.01); *H01R 11/15*
(2013.01); *H01R 13/207* (2013.01); *H01R*
13/53 (2013.01); *H01R 4/56* (2013.01); *H01R*
13/447 (2013.01); *H01R 13/648* (2013.01);

(57)

ABSTRACT

An elbow-type power cable electrical connector includes a connector body having a bushing receiving end projecting substantially perpendicularly from the connector body and a connection end projecting substantially perpendicularly from the connector body and oriented substantially opposite to the bushing receiving end, wherein the bushing receiving end is configured to receive a switchgear bushing therein. A grounding device is configured for insertion into the connection end of the connector, wherein the grounding device is configured to conductively connect to the switchgear bushing. The grounding devices include an exposed conductive portion configured to engage a grounded hot line clamp, during grounding of the electrical connector assembly. An insulated cap is provided to cover the exposed conductive portion of the grounding device during normal operation of the electrical connector.

17 Claims, 13 Drawing Sheets



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- (51) **Int. Cl.**
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FIG. 1A

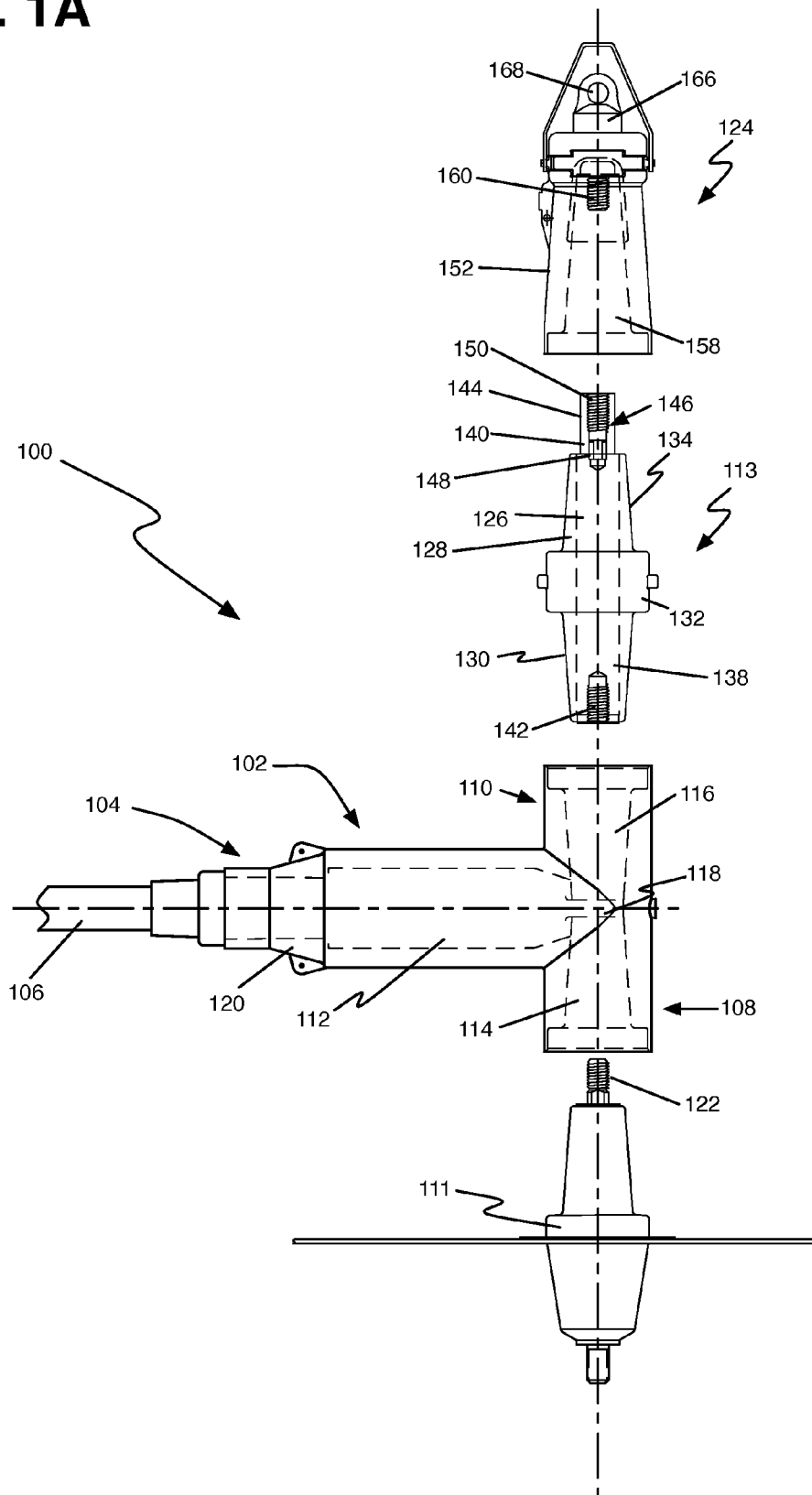


FIG. 1B

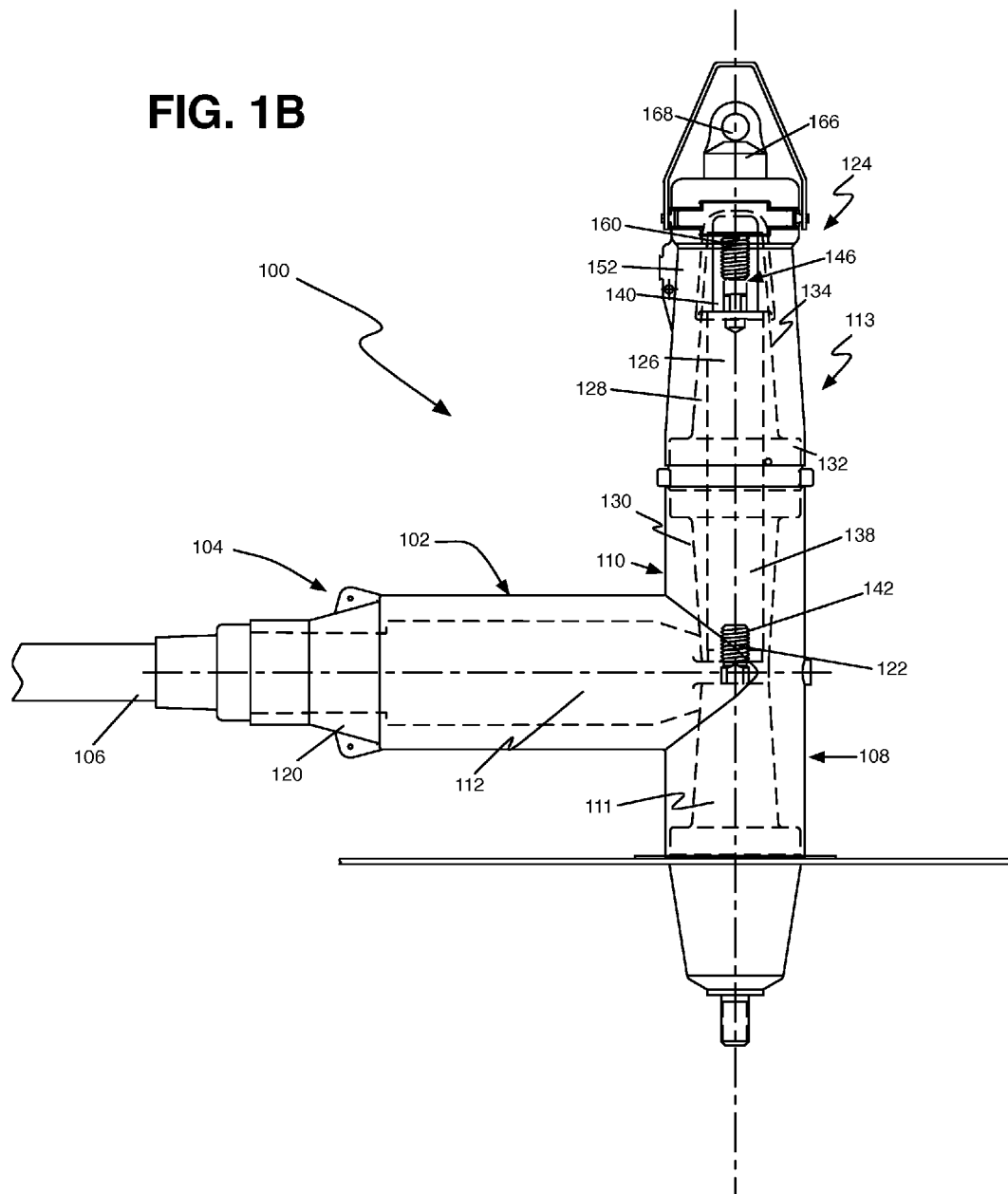


FIG. 2

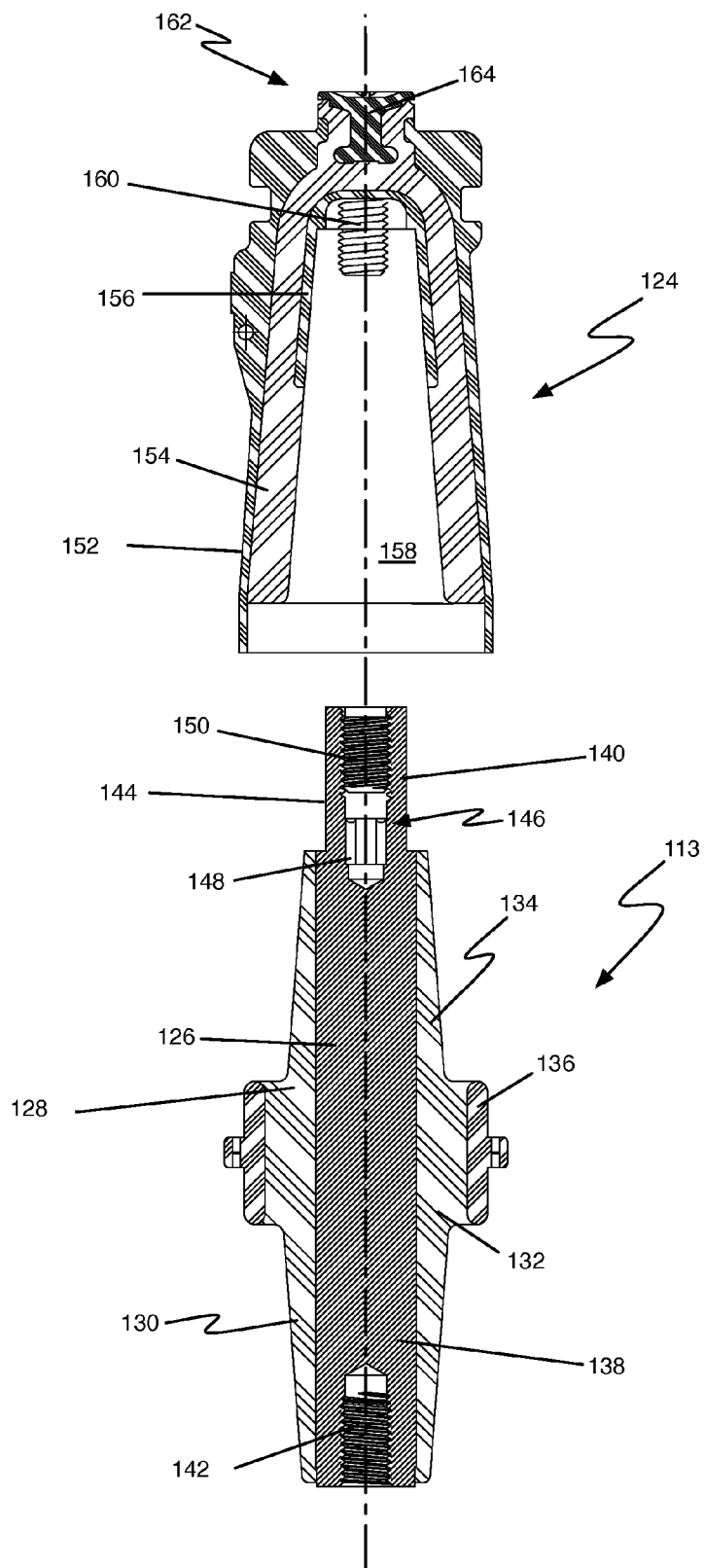


FIG. 3

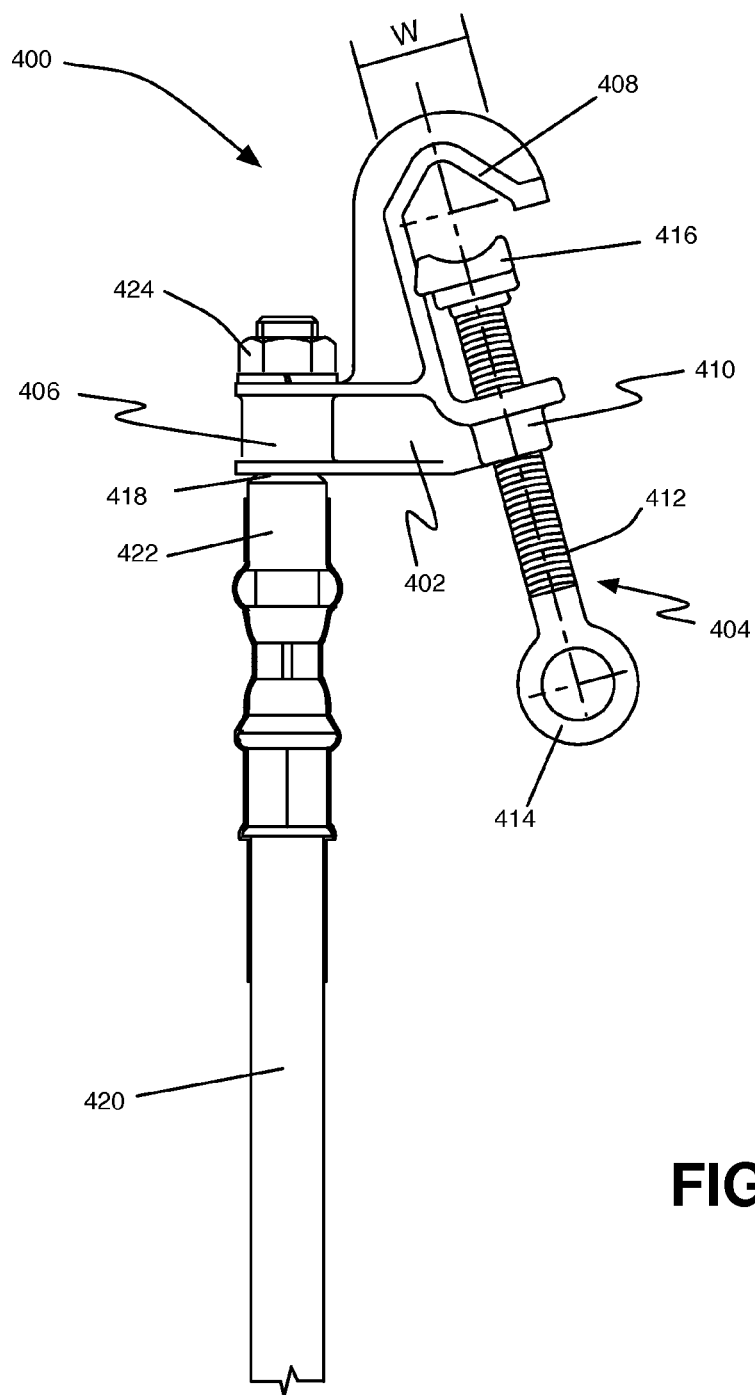


FIG. 4

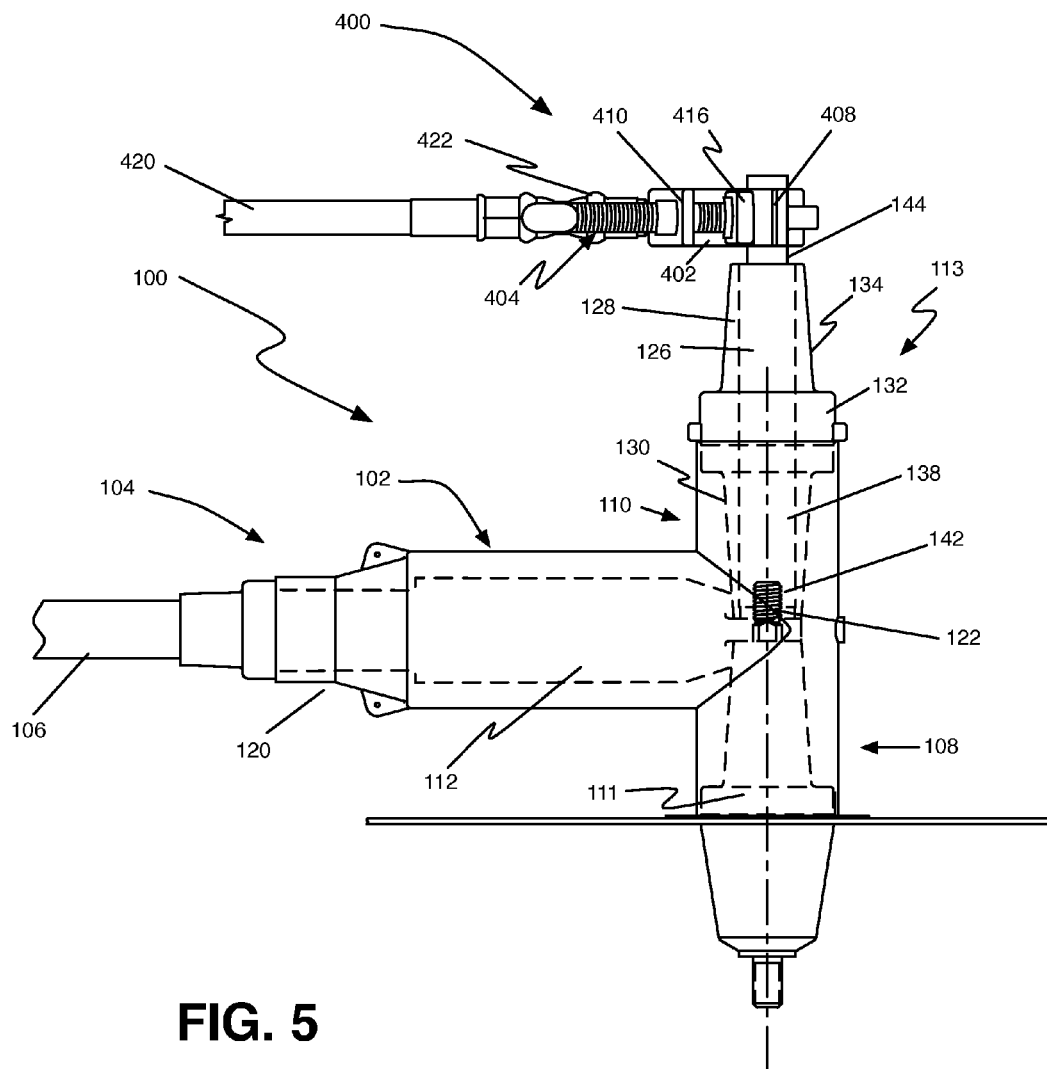
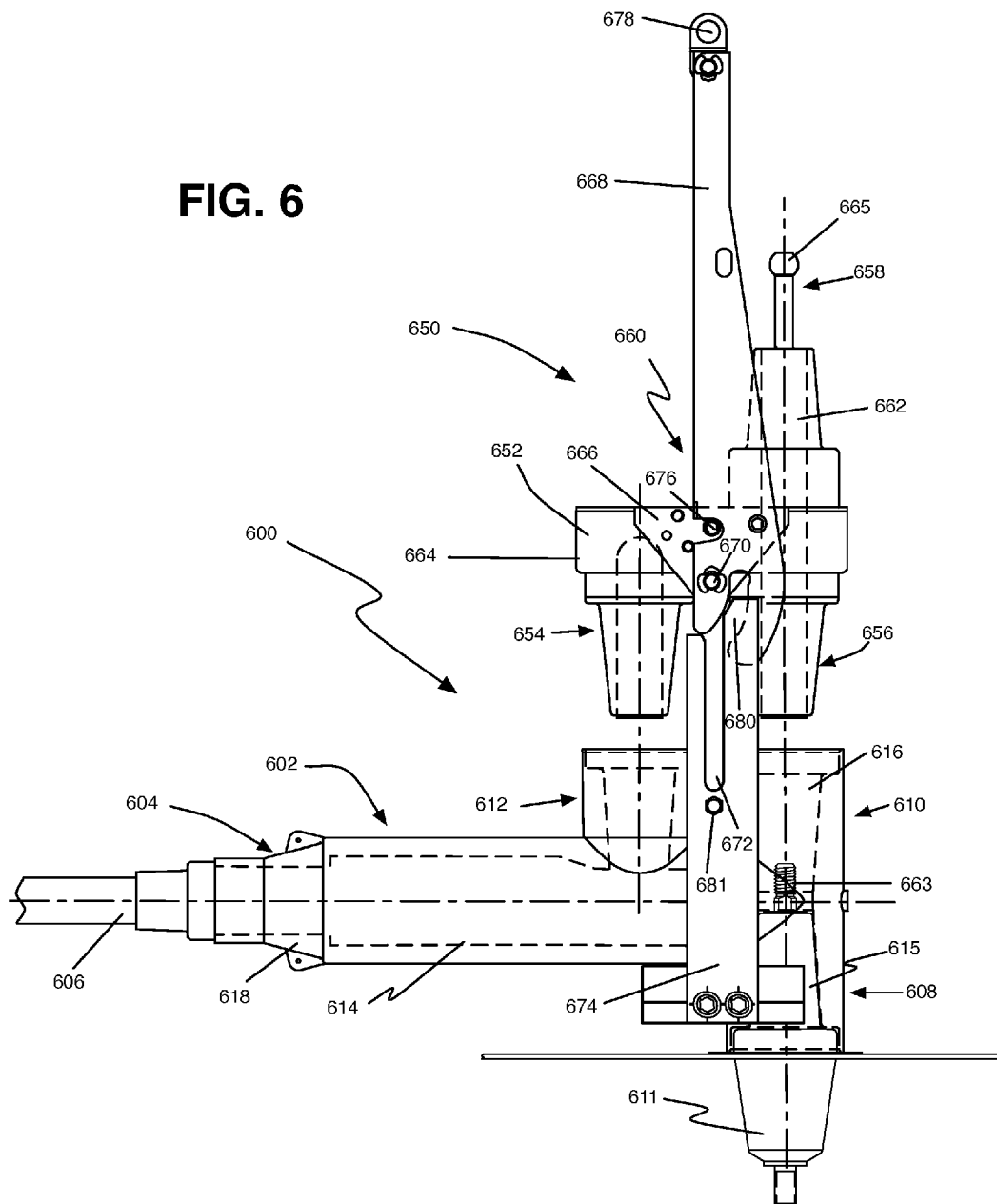


FIG. 6



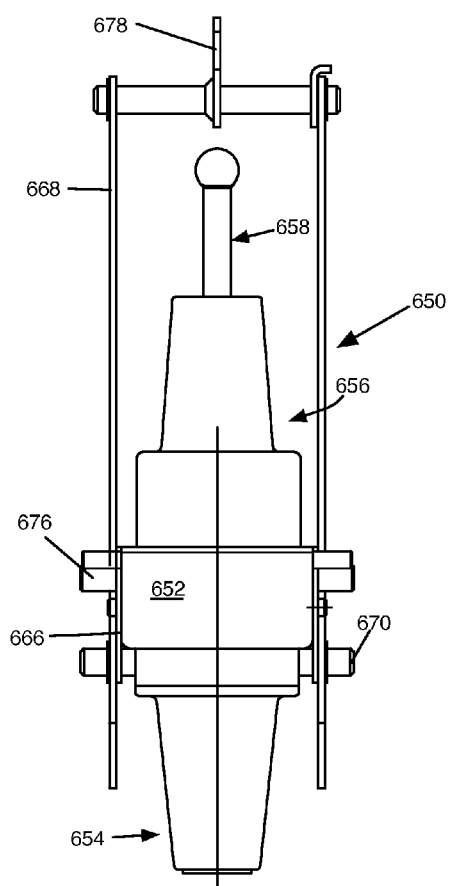


FIG. 7A

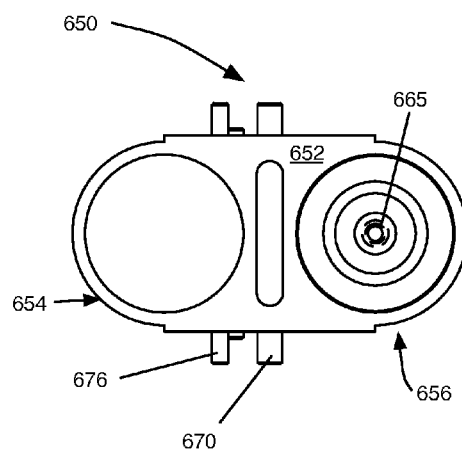


FIG. 7B

FIG. 8A

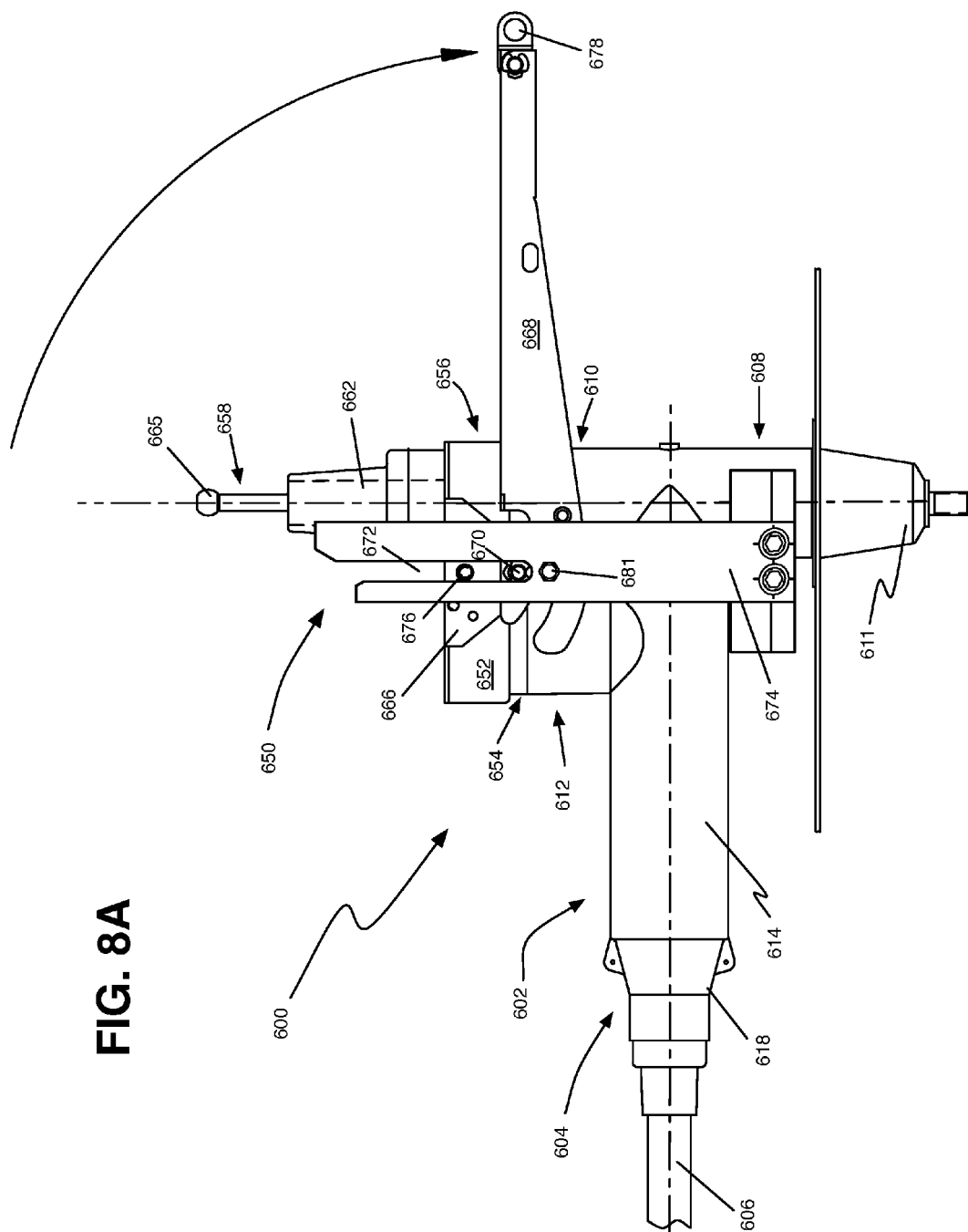
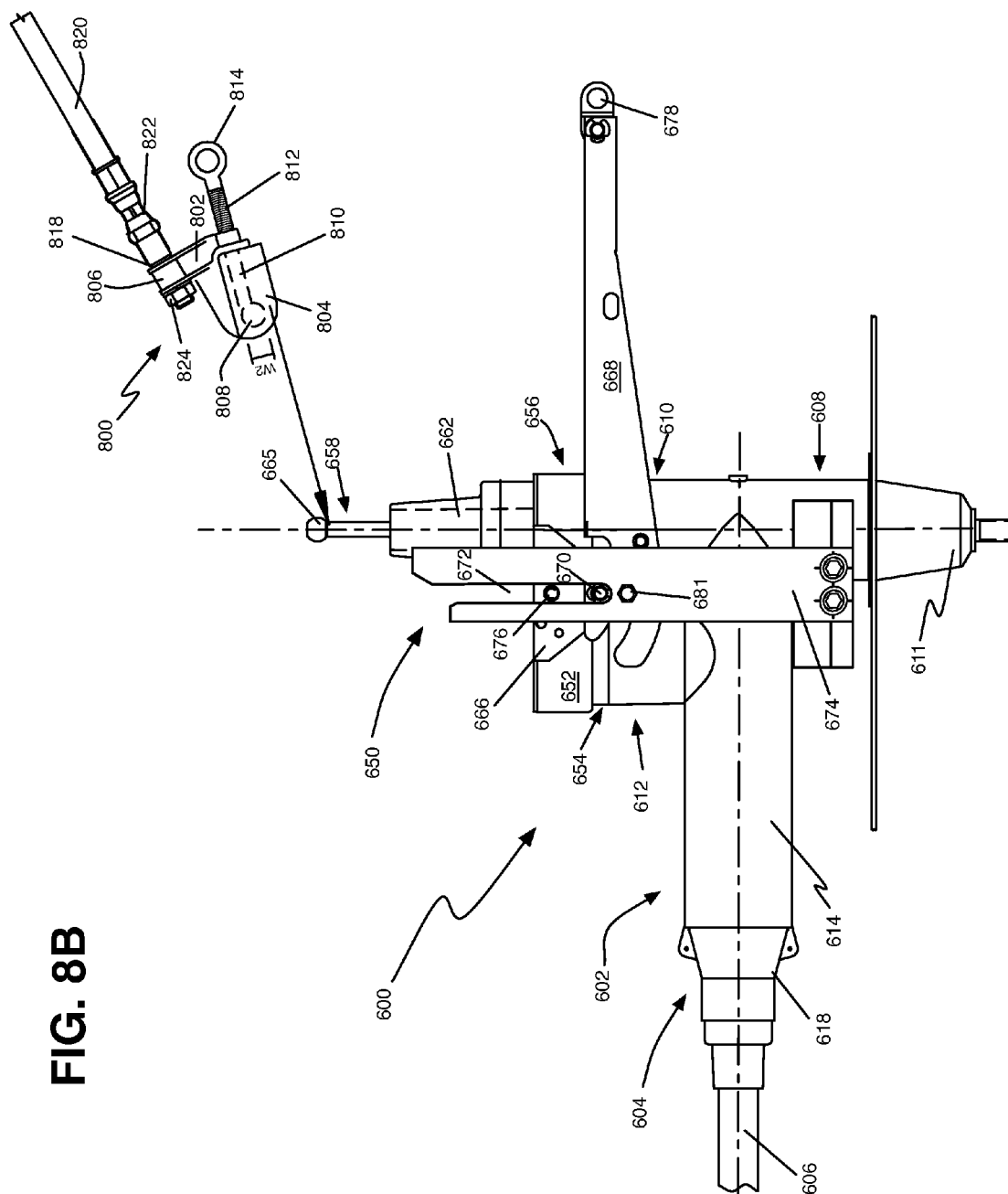


FIG. 8B



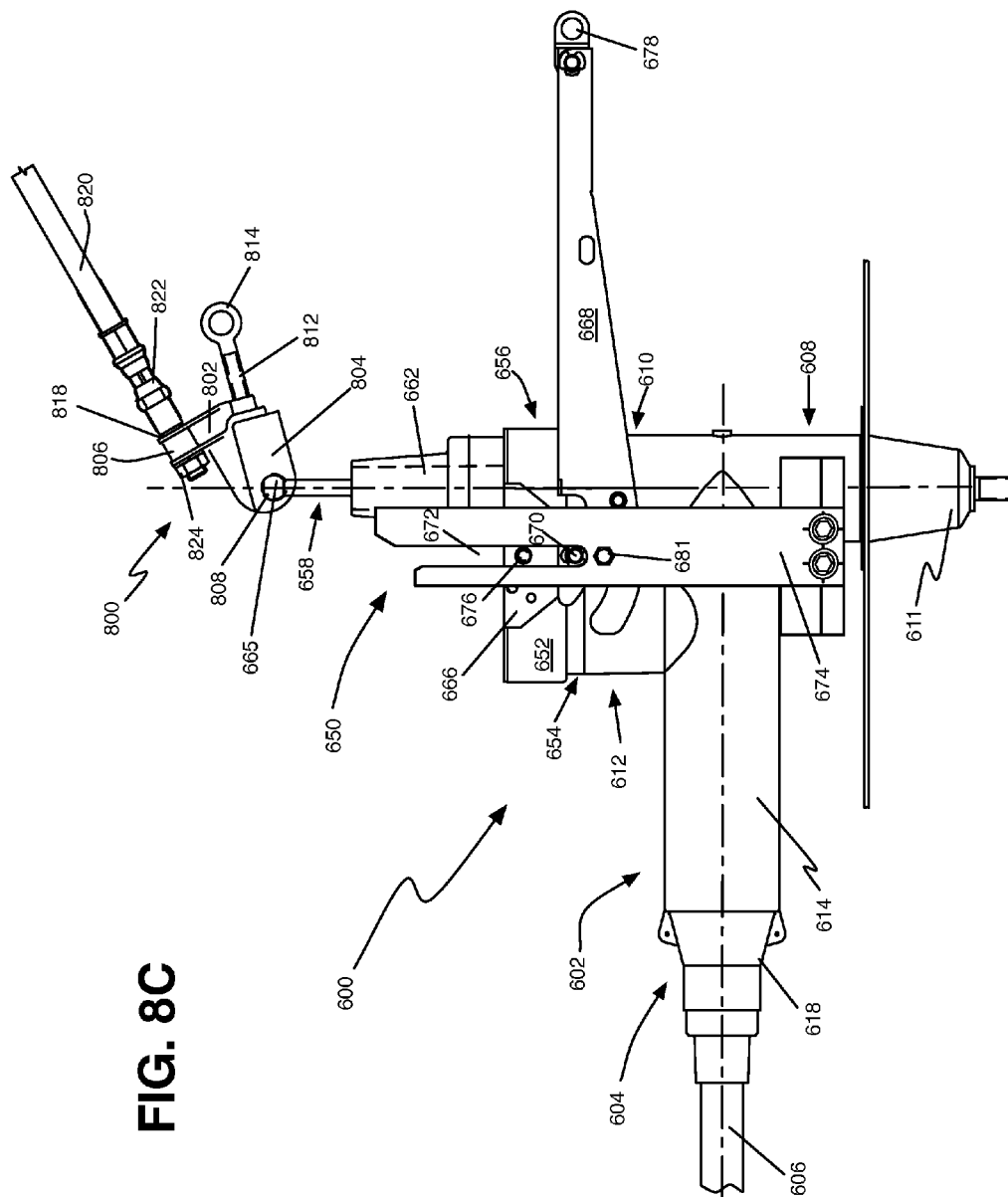
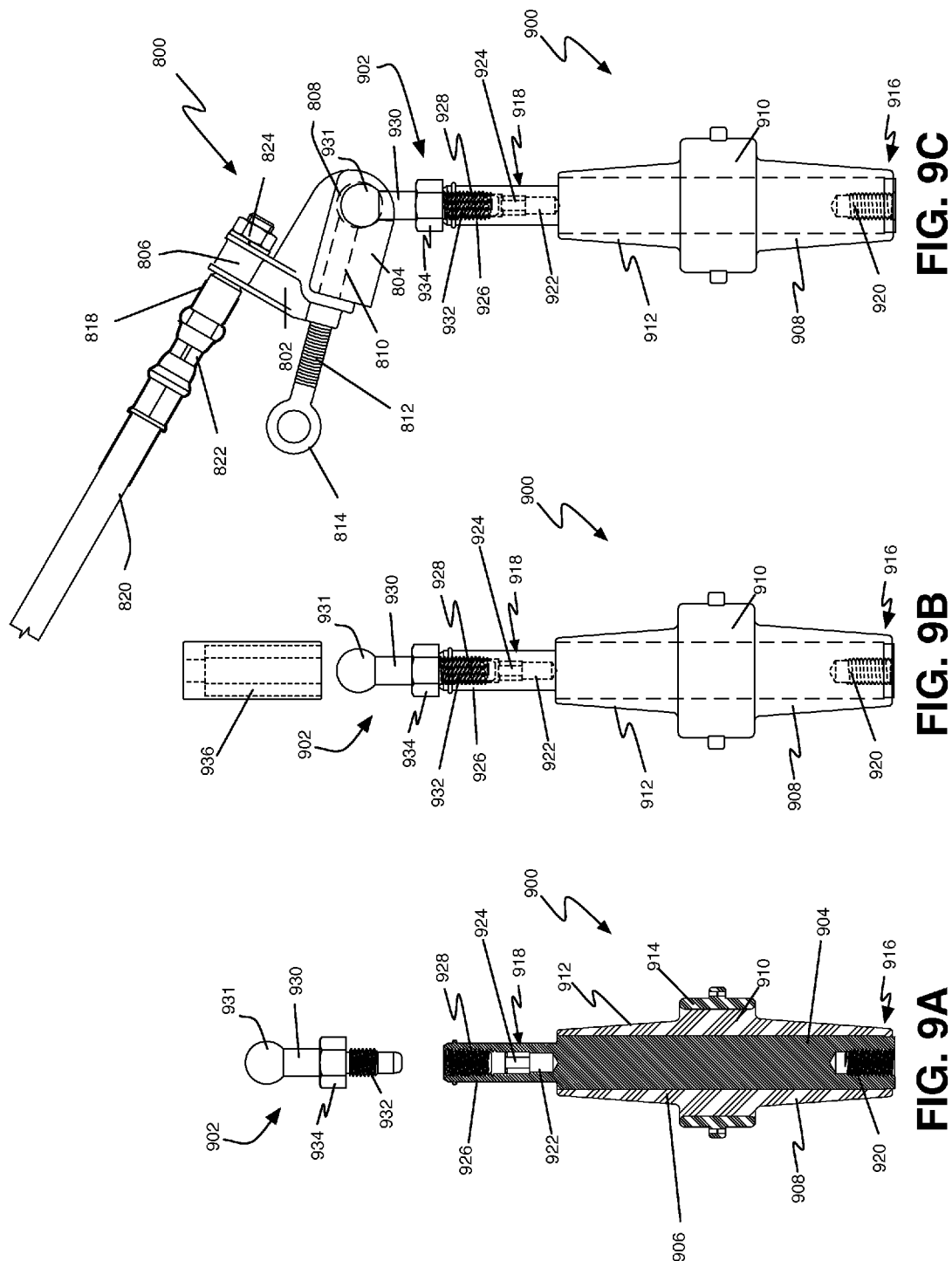
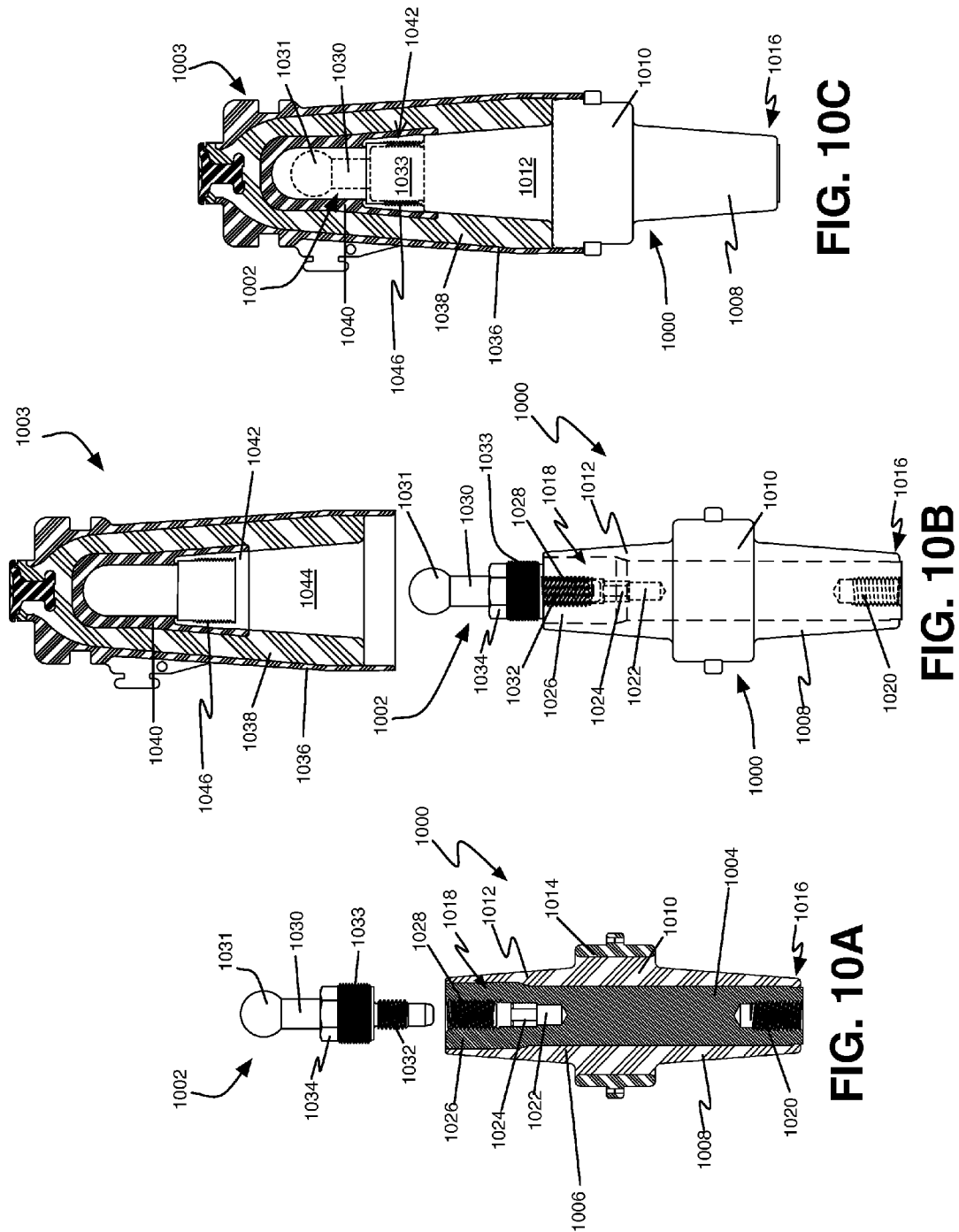


FIG. 8C





1

ELECTRICAL CONNECTOR HAVING GROUNDING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. §119, based on U.S. Provisional Patent Application No. 61/673,469, filed Jul. 19, 2012, the disclosure of which is hereby incorporated by reference herein

BACKGROUND OF THE INVENTION

The present invention relates to electrical cable connectors, such as loadbreak connectors and deadbreak connectors. More particularly, aspects described herein relate to an electrical cable connector, such as a power cable elbow or T-connector connected to electrical switchgear assembly.

Loadbreak connectors used in conjunction with 15 and 25 KV switchgear generally include a power cable elbow connector having one end adapted for receiving a power cable and another end adapted for receiving a loadbreak bushing insert or other switchgear device. The end adapted for receiving the bushing insert generally includes an elbow cuff for providing an interference fit with a molded flange on the bushing insert.

In some implementations, the elbow connector may include a second opening formed opposite to the bushing insert opening for facilitating connection of the elbow connector to the bushing and to provide conductive access to the power cable by other devices, such as a surge arrestor, a tap plug, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a schematic, exploded side view illustrating a power cable electrical connector consistent with implementations described herein;

FIG. 1B is a schematic side view of the power cable elbow connector of FIG. 1A in an assembled configuration.

FIG. 2 is a cross-sectional view of the grounding device and insulated cap of FIG. 1;

FIG. 3 is a schematic side view of the electrical connector of FIG. 1 in a partially disassembled configuration;

FIG. 4 is a schematic side view of an exemplary hot line clamp;

FIG. 5 is a schematic side view of the hot line clamp of FIG. 4 coupled to the elbow connector of FIG. 3 in a manner consistent with embodiments described herein;

FIG. 6 is a schematic, partially exploded, side view diagram of another embodiment of a power cable elbow connector consistent with embodiments described herein;

FIGS. 7A and 7B are end and top views, respectively, of the grounding cam-op link assembly of FIG. 6;

FIGS. 8A-8C are side view illustrations of the power cable elbow connector of FIG. 1 during installation and use of the grounding cam-op link assembly;

FIGS. 9A-9C are side view illustrations of another exemplary grounding device consistent with embodiments described herein; and

FIGS. 10A-10C are combined side/cross-sectional views of still another exemplary grounding device and insulated cap consistent with embodiments described herein.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

2

FIG. 1A is a schematic exploded side view of a power cable elbow connector **100** consistent with implementations described herein. FIG. 1B is a schematic side view of the power cable elbow connector **100** in an assembled configuration. As shown, power cable elbow connector **100** may include a main housing body **102** that includes a conductor receiving end **104** for receiving a power cable **106** therein and first and second T-ends **108/110** that include openings for receiving an equipment bushing, such as a deadbreak or loadbreak transformer bushing **111** or other high or medium voltage terminal, such as an insulating plug, or other power equipment. Consistent with implementations described herein, second T-end **110** may be configured to receive a grounding device **113** described in additional detail below.

As shown, conductor receiving end **104** may extend along a main axis of connector **100** and may include a bore **112** extending therethrough. First and second T-ends **108/110** may project substantially perpendicularly from conductor receiving end **104** in opposing directions from one another. First and second T-ends **108/110** may include bores **114/116**, respectively, formed therethrough for receiving equipment, bushings, and/or plugs. A contact area **118** may be formed at the confluence of bores **112**, **114**, and **116**.

Power cable elbow connector **100** may include an electrically conductive outer shield **120** formed from, for example, a conductive peroxide-cured synthetic rubber, commonly referred to as EPDM (ethylene-propylene-dienemonomer). Within shield **120**, power cable elbow connector **100** may include an insulative inner housing, typically molded from an insulative rubber or epoxy material, and a conductive or semi-conductive insert that surrounds the connection portion of power cable **106**.

As shown in FIG. 1A, bushing **111** may include a stud portion **122** projecting axially therefrom. During assembly of elbow connector **100** onto bushing **111**, as shown in FIG. 1B, stud portion **122** of bushing **111** is received into contact area **118** and extend through an opening in a spade portion coupled to power cable **106** (not shown).

Consistent with embodiments described herein, grounding device **113** may be configured to conductively couple to power cable **106** and bushing **111**. In an initial configuration, an insulated cap **124** may be installed onto grounding device **113**. FIG. 2 is a detailed cross-sectional view of grounding device **113** and insulated cap **124**.

As shown in FIG. 2, grounding device **113** includes a conductive core portion **126** and an insulated body **128**. In one implementation, insulated body **128** may include a first tapered portion **130**, a central portion **132**, and a second tapered portion **134**. As shown, first portion **130** includes a tapered configuration for seating within bore **116** in second T-end **110** of main housing body **102**.

Central portion **132** includes a generally cylindrical configuration having a larger diameter than an interior end of first tapered portion **130**. During assembly, as shown in FIG. 1B, central portion **132** abuts an outer surface of second T-end **110**.

Second tapered portion **134** projects from central portion **132** in an axial direction away from first tapered portion **132** and includes a tapered configuration for receiving a cavity **158** in insulated cap **124** (described below). Consistent with embodiments described herein, insulated body **128** may be formed of an insulative rubber or epoxy material. Furthermore, as shown in FIG. 2, central portion **132** may include an outer shield portion **136** formed on a radial periphery thereof. Outer shield portion **136** may be formed of a conductive or semi-conductive material, such as EPDM. As shown in FIG. 1B, following assembly, outer shield portion **136** of ground-

3

ing device 113 remains exposed. By providing outer shield portion 136 of a conductive material (similar to main housing body 102), electrical continuity is maintained throughout an exterior of the assembled connector 100.

As shown in FIG. 2, conductive core 126 includes a substantially cylindrical configuration that extends through an interior of insulated body 128. Conductive core 126 includes a stud receiving end 138 and a clamp engaging end 140 that projects beyond an end of insulated body 128. Conductive core 126 may be formed of a conductive material, such as brass, steel, or aluminum and, upon assembly, may conductively couple with power cable 106 and bushing 112 via stud portion 122.

In one embodiment, stud receiving end 138 may include a threaded opening 142 for matingly engaging corresponding threads on stud portion 122 of bushing 111, although other means for coupling with stud portion 122 may be incorporated, such as a push or snap-on connection, etc. Furthermore, in some implementations, the male/female relationship of stud portion 122 and stud receiving end 138 may be reversed.

As shown in FIG. 2, clamp engaging end 140 includes a clamp engaging outer surface 144 and a multi-function bore 146 formed axially therein. As shown, clamp engaging outer surface 144 extends beyond an end of second tapered end 134 of insulated body 128. As described in detail below, clamp engaging outer surface 144 provides an engagement surface for engaging a hot line clamp or other suitable ground clamp device. Although clamp engaging outer surface 144 is depicted in FIG. 2 as having a smooth configuration, in other implementations, clamp engaging outer surface 144 may be provided with a high friction surface, such as a grooved or knurled surface to facilitate secure clamping.

Multi-function bore 146 extends axially within clamp engaging end 140 of conductive core 126 and includes a grounding device attachment portion 148 and cap securing portion 150. As shown in FIG. 2, grounding device attachment portion 148 of multi-function bore 146 may be formed on the interior of multi-function bore 146 and includes a tool engaging configuration for receiving a tool, such as a hex wrench, therein.

During assembly of elbow connector 100, first tapered portion 130 and stud receiving end 138 of grounding device 113 are inserted into bore 116 in second T-end 110. Threaded opening 142 in conductive core 126 may be threaded onto stud portion 122 of bushing 111. A suitable tool is then inserted into multi-function bore 146 and into engagement with grounding device attachment portion 148. The tool is then rotated to secure grounding device 113 within second T-end 110. Although grounding device attachment portion 148 is depicted in FIG. 2 as including a hexagonal surface configuration, in other embodiments, different types of tool engaging configurations may be used, such as flat or Phillips head configurations, a Torx configuration, a 12-sided configuration, etc.

As shown in FIG. 2, cap securing portion 150 of multi-function bore 146 may include an internally threaded configuration for use in securely retaining insulated cap 124. Insulated cap 124 may include an outer conductive or semi-conductive shield 152, an insulative inner housing 154, typically molded from an insulative rubber or epoxy material, and a conductive or semi-conductive insert 156 that surrounds clamp engaging end 140 of conductive core 126 once insulated cap 124 is installed on grounding device 113.

As shown in FIG. 2, insulated cap 124 includes a substantially conical cavity 158 formed therein for receiving clamp engaging end 140 and second tapered portion 134 of grounding device 113. As described briefly above, the conical con-

4

figuration of cavity 158 corresponds to the tapered configuration of second tapered portion 134 to allow insulated cap 124 to become seated on grounding device 113 during installation. Furthermore, as shown in FIG. 2, insulated cap 124 may include an engagement stud 160 having a threaded outer surface for engaging threaded cap securing portion 150 of multi-function bore 146 in conductive core 126. During assembly, engagement stud 160 may be threaded into cap securing portion 150 and tightened to secure insulated cap 124 to grounding device 113.

In one exemplary implementation, insulated cap 124 may include a voltage detection test point assembly 162 for sensing a voltage in connector 100. Voltage detection test point assembly 162 may be configured to allow an external voltage detection device to detect and/or measure a voltage associated with elbow connector 100.

For example, as illustrated in FIG. 2, voltage detection test point assembly 162 may include a test point terminal 164 embedded in a portion of insulative inner housing 154 of insulated cap 124 and extending through an opening within outer shield 152. In one exemplary embodiment, test point terminal 164 may be formed of a conductive metal or other conductive material. In this manner, test point terminal 164 may be capacitively coupled to conductive core 126 of grounding device 113 upon installation of insulated cap to grounding device 113.

As shown in FIGS. 1A and 1B, a test point cap 166 may sealably engage an exposed portion of test point terminal 164 and outer shield 152. In one implementation, test point cap 166 may be formed of a semi-conductive material, such as EPDM. When test point terminal 164 is not being accessed, test point cap 166 may be mounted on test point assembly 162. Because test point cap 166 is formed of a conductive or semiconductive material, test point cap 166 may ground test point assembly 162 when in position. Test point cap 166 may include an aperture 168 for facilitating removal, e.g., using a hooked lineman's tool. In addition, insulated cap 124 may include a bailing assembly for use in securing cap 124 and grounding device 113 to elbow connector 100.

When it is desired to perform work on a particular line or switchgear component, it is necessary to ensure that the system is properly de-energized and grounded before work can begin. Consistent with embodiments described herein, to accomplish this, a technician first tests connector 100, e.g., using voltage detection test point assembly 162, to ensure that connector 100 has been de-energized. If the test indicates that the connector 100 is de-energized, insulated cap 124 is removed (e.g., by unscrewing) from grounding device 113. FIG. 3 is a schematic side view of connector 100 in a partially disassembled configuration, e.g., after removal of insulated cap 124 from grounding device 113. As shown in FIG. 3, in this configuration, clamp engaging end 140 of conductive core 126 is exposed.

FIG. 4 is a schematic side view of an exemplary hot line clamp 400. FIG. 5 is a schematic side view of hot line clamp 400 coupled to elbow connector 100 in a manner consistent with embodiments described herein.

Referring to FIG. 4, in one exemplary implementation, hot line clamp 400 includes a conductive body 402, a clamping member 404, and a ground line attachment portion 406. Conductive body 402 may be formed of a conductive metal, such as brass or aluminum and may include a generally v or c-shaped region 408 for receiving a portion of clamp engaging end 140 of conductive core 126. For example, a width "W" may be substantially similar, yet slightly larger than an outside diameter of clamp engaging end 140. With such a

5

configuration, v-shaped region **408** may easily slip onto exposed clamp engaging end **140** following removal of insulated cap **124**.

As shown in FIG. 4, conductive body **402** may include an opposing portion **410** projecting from body **402** in a location opposing v-shaped region **408**. Opposing portion **410** includes a threaded aperture therethrough configured to receive clamping member **404**, such that clamping member is positioned in clamping relation to v-shaped region **408**.

Clamping member **404**, in one exemplary embodiment, includes a generally cylindrical, threaded body **412** having a tool engaging portion **414** on one end and a part engagement portion **416** on an opposing end, distal from tool engaging portion **414**. During assembly of hot line clamp **400**, body **412** is threaded through opposing portion **410** such that part engagement portion **416** opposes v-shaped region **408**.

As shown in FIG. 5, during connection of hot line clamp **400** to elbow connector **100**, v-shaped region **408** of conductive body **402** is placed over the exposed clamp engaging end **140** of ground device **113**. Tool engaging portion **414** of clamping member **404** is then rotated, e.g., using a lineman's hook, causing part engaging portion **416** to travel toward v-shaped region **408**, thus securing clamp engaging end **140** of grounding device **113** within hot line clamp **400**.

Returning to FIG. 4, conductive body **402** of hot line clamp **400** also includes an aperture **418** for receiving ground line attachment portion **406**. Ground line attachment portion **406** may include a mechanism for securing a ground line **420** to, for example, a threaded lug **422**. In one implementation, ground line attachment portion **406** may include a crimp style connector for securing ground line **420** to lug **422**. As shown in FIG. 4, lug **422** may be inserted into aperture **418** in conductive body **402** and secured using nut **424**.

Embodiments described herein increase the efficiency with which work may be performed on a power line or switchgear component by providing an efficient means for grounding elbow connector **100** without requiring disassembly of the connector or replacement of the connector with a single-purpose grounding component. Rather, grounding device **113** is maintained within elbow connector **100** for use when needed. When grounding is not needed, insulated cap **124** may be reinstalled and power cable elbow connector **100** may operate in a conventional manner.

FIG. 6 is a schematic, partially exploded, side view diagram of another power cable elbow connector **600** consistent with embodiments described herein. FIGS. 7A and 7B are end and top views, respectively, of a grounding cam-op link assembly **650**. FIGS. 8A-8C are side view illustrations of power cable elbow connector **600** during installation and use of grounding cam-op link assembly **650**.

As shown in FIG. 6, power cable elbow connector **600** includes a body portion **602**, a conductor receiving end **604** for receiving a power cable **606** therein (also referred to as the "line"), first and second T-ends **608/610** distal from conductor receiving end **604** that include openings for receiving a dead-break transformer bushing **611**, or other high or medium voltage terminals (also referred to as the "load"), such as an insulating plug, or other power equipment (e.g., a tap, a voltage arrester, etc.). Power cable elbow connector **600** further includes a link interface **612**, which, in combination with second T-end **610** receives a cam-op link therein. Although not shown in FIG. 6, power cable elbow connector **600** includes equipment for terminating power cable **606** in a manner that is electrically isolated from first and second T-ends **608/610**. A cam-op link (not shown) is used to bridge the conductive gap between power cable **606** and bushing **611**.

6

As shown, conductor receiving end **604** may extend along a main axis of connector **600** and may include a bore **614** extending therethrough. First and second T-ends **608/610** may project substantially perpendicularly from conductor receiving end **604** in opposing directions from one another. Link interface **612** may also project perpendicularly from conductor receiving end **604** in a direction parallel to second T-end **610**. First and second T-ends **608/610** may include bores **615/616**, respectively, formed therethrough for receiving bushing **611**, and one of the legs of a cam-op link (not shown), respectively. As briefly described above, link interface **612** may receive the other leg of the cam-op link during assembly. Moreover, link interface **612** may include a conductive stud (not shown) that is electrically coupled to power cable **606**. A leg of cam-op link inserted into link interface **612** includes a stud receiving portion for receiving the conductive stud, to facilitate electrical contact from bushing **611** to power cable **606** via the cam-op link.

Similar to power cable elbow connector **100** described above, power cable elbow connector **600** may include an electrically conductive outer shield **618** formed from, for example, a conductive or semi-conductive peroxide-cured synthetic rubber, such as EPDM. Further, although not shown in the Figures, power cable elbow connector **600** may further include an insulative inner housing, typically molded from an insulative rubber or silicon material, and a conductive or semi-conductive insert that surrounds the connection portion of power cable **106**. As briefly described above, the area between first and second T-ends **608/610** and link interface **612** may be filled with an insulative material, so as to electrically isolate first and second T-ends **608/610** from link interface **612**.

Consistent with embodiments described herein, when it becomes necessary to ground the "load" side of connector **600** (e.g., bushing **611**), the cam-op link may be removed and a grounding cam-op link assembly **650** may be installed within second T-end **610** and link interface **612**.

As shown in FIG. 6, grounding cam-op link assembly **650** includes link body portion **652**, rearward link interface bushing **654**, forward link interface bushing **656**, grounding interface **658**, and link engagement assembly **660**. Grounding cam-op link **650** may be configured to provide a grounded interface for terminal bushing **611**, which is electrically isolated from power cable **606**.

As shown in FIG. 6, link body portion **652** extends substantially axially with rearward and forward link interface bushings **654/656** projecting substantially perpendicularly therefrom. Although not shown in the Figures, rearward link interface bushing **654** includes a stud receiving bus for receiving the conductive stud couple to power cable **606**. Upon installation into connector **600**, rearward link interface bushing **654** may be configured to align with (and sized for insertion into) link interface **612** and forward link interface bushing **656** may be configured to align with (and sized for insertion into) second T-end **610**, as shown in FIGS. 8A and 8B.

Forward link interface bushing **656** may include a conductive core **662** extending therethrough. Similar to conductive core **126** of grounding device **113** described above, conductive core **662** is configured to interface with stud **663** in bushing **611**, such as via correspondingly threaded engagement. Grounding interface **658** extends from conductive core **662** and projects above a surface of link body portion **652**.

As shown in FIG. 6, in one implementation, grounding interface **658** includes a ball end **665**, designed to engage with a suitably sized ball socket clamp (element **800** in FIGS. 8B and 8C), as described in detail below. Conductive core **662**

and grounding interface **658** may be formed as one element of conductive material, such as copper, brass, steel, or aluminum. In other implementations, grounding interface **658** may be separate from a secured to conductive core **662**.

Grounding cam-op link assembly **650** may include an electrically conductive outer shield **664** formed from, for example, EPDM. Within shield **664**, grounding cam-op link assembly **650** may include an insulative inner housing. In some embodiments, a portion of outer shield **664** and inner housing between the rearward and forward link interface bushings **654/656** may be provided with a viewing port extending therethrough for visually ensuring the absence of a conductive link between link interface **612** and bushing **611**.

As shown in FIG. 6, link engagement assembly **660** may include a link arm bracket **666** and a link arm **668**. Link arm bracket **666** may be secured to grounding cam-op link **600** (e.g., via one or more bolts, etc.). Link arm **668** may, in turn, be rotatably secured to link arm bracket **666** via a pivot pin **670**. In some implementations, pivot pin **670** may extend from link arm **668** to engage a corresponding slot **672** in a cam-op link bracket **674** connected to elbow connector **600**. Link arm bracket **666** may include a stop **676** for preventing link arm **668** from rotating past a vertical orientation and a hole **678** in an end of link arm **668** distal from pivot pin **670**, for enabling engagement of link arm **668** by a suitable tool, such as a hotstick or lineman's tool. Downward movement of the tool may cause link arm **668** to rotate downward about pivot pin **670** toward rearward link interface bushing **654** and forward link interface bushing **656**.

Link arm **668** may also include a curved clamp pin engagement slot **680** for engaging a corresponding clamp pin in cam-op link bracket **674**. Rotation of link arm **668** about pivot pin **670** when grounding cam-op link assembly **650** is installed in connector **100** (as shown in FIG. 8A) may cause clamp pin engagement slot **680** to slidably engage clamp pin **681**, thereby securing grounding cam-op link assembly **650** to connector **600**.

Once installed within link interface **612** and second T-end **610**, as shown in FIGS. 8B and 8C, ball socket clamp **800** may be installed on grounding interface **658**. In one exemplary implementation, ball socket clamp **800** includes a conductive body **802**, a clamping member **804**, and a ground line attachment portion **806**. Conductive body **802** may be formed of a conductive metal, such as brass or aluminum and may include a socket portion **808** formed therein for receiving ball end **665** of grounding interface **658**. For example, a width "W2" may be substantially similar, yet slightly larger than an outside diameter of ball end **665**. With such a configuration, socket portion **808** may easily slip onto exposed ball end **665** following installation of grounding cam-op link **650** into elbow connector **600**.

As shown in FIG. 8B, conductive body **802** may include a threaded aperture **810** for receiving clamping member **804**, such that clamping member **804** is positioned in clamping relation to socket portion **808**. Clamping member **804**, in one exemplary embodiment, includes a generally cylindrical, threaded body **812** having a tool engaging portion **814** on one end and a ball engaging portion (not shown) on an opposing end, distal from tool engaging portion **814**. During assembly of ball socket clamp **800**, body **812** is threaded through aperture **810** such that the ball engaging portion engages ball end **665** of grounding interface **658**.

As shown in FIG. 8C, during connection of ball socket clamp **800** to grounding interface **658**, socket portion **808** of conductive body **802** is placed over exposed ball end **665** of grounding interface **658**. Tool engaging portion **814** of clamping member **804** is then rotated, e.g., using a lineman's hook,

causing the ball engaging portion to travel toward socket portion **808**, thus securing ball end **665** of grounding interface **658** within ball socket clamp **800**.

As shown in FIGS. 8B and 8C, conductive body **802** of ball socket clamp **800** also includes an aperture **818** for receiving ground line attachment portion **806**. Ground line attachment portion **806** may include a mechanism for securing a ground line **820** to, for example, a threaded lug **822**. In one implementation, ground line attachment portion **806** may include a crimp style connector for securing ground line **820** to lug **822**. Lug **822** may be inserted into aperture **818** in conductive body **802** and secured using nut **824**.

Embodiments described herein increase the efficiency with which work may be performed on a power line or switchgear component by providing an efficient means for grounding elbow connector **600**. More specifically, a conventional cam-op link assembly may be easily removed and replaced with grounding cam-op link assembly **650**. The grounding interface **658** of grounding cam-op link assembly may then be coupled to a grounded ball socket clamp **800** to facilitate grounding of connector **600**.

FIGS. 9A-9C are side view illustrations of another exemplary grounding device consistent with embodiments described herein. In particular, FIG. 9A is a cross-sectional diagram illustrating an exemplary grounding device **900** and grounding interface **902** in a pre-assembled configuration. FIG. 9B is a side view of grounding device **900** and grounding interface **902** in an assembled configuration. FIG. 9C is a side view of grounding device **900** and grounding interface **902** showing ball socket clamp **800** installed on grounding interface **902**.

Consistent with embodiments described herein, grounding device **900**, similar to grounding device **113** described above, includes a conductive core portion **904** and an insulated body **906**. In one implementation, insulated body **906** includes a first tapered portion **908**, a central portion **910**, and a second tapered portion **912**.

Central portion **910** includes a generally cylindrical configuration having a larger diameter than an interior end of first tapered portion **906**. During assembly, central portion **910** abuts an outer surface of second T-end **110** in power cable elbow connector **100**.

Second tapered portion **912** projects from central portion **910** in an axial direction away from first tapered portion **908** and includes a tapered configuration for receiving an insulated cap, similar to insulated cap **124** described above in relation to FIGS. 1 and 2.

Insulated body **906** may be formed of an insulative rubber or epoxy material. Furthermore, in some embodiments, central portion **910** includes an outer shield portion **914** formed on a radial periphery thereof. Outer shield portion **914** may be formed of a conductive or semi-conductive material, such as EPDM.

Conductive core **904** includes a substantially cylindrical configuration that extends through an interior of insulated body **906**. Conductive core **904** includes a stud receiving end **916** and a grounding interface receiving end **918** that projects beyond an end of insulated body **906**. Conductive core **904** may be formed of a conductive material, such as brass, steel, or aluminum and, upon assembly, may conductively couple with power cable **106** and bushing **112** in power cable elbow connector **100**.

In one embodiment, stud receiving end **916** includes a threaded opening **920** for matingly engaging corresponding threads on a bushing, such as bushing **111** described above.

However, in other embodiments, other means for coupling with the bushing may be incorporated, such as a push or snap-on connection, etc.

As shown in FIG. 9A, grounding interface receiving end **918** includes a substantially cylindrical outer surface **144** and a multi-function bore **922** formed axially therein. As shown, grounding interface receiving end **918** extends beyond an end of second tapered end **912** of insulated body **906**. As described in detail below, grounding interface receiving end **918** is configured to receive and secure grounding interface **902** to grounding device **900**.

Multi-function bore **922** extends axially within grounding interface receiving end **918** and includes a grounding device attachment portion **924** and grounding interface/insulated cap securing portion **926**. Grounding device attachment portion **924** of multi-function bore **922** may be formed on the interior of multi-function bore **922** and includes a tool engaging configuration for receiving a tool, such as a hex wrench, therein.

During assembly of grounding device **900** to elbow connector **100**, first tapered portion **908** of grounding device **900** is inserted into bore **116** in second T-end **110** of connector **100**. Threaded opening **920** in stud receiving end **916** in conductive core **904** may be threaded onto stud portion **122** of bushing **111**. A suitable tool is then inserted into multi-function bore **922** and into engagement with grounding device attachment portion **924**. The tool is then rotated to secure grounding device **900** within second T-end **110**.

As shown in FIG. 9A, grounding interface/insulated cap securing portion **926** of multi-function bore **922** may include an internally threaded portion **928** for use in securely retaining both grounding interface **902** and an insulated cap, such as insulated **124**, described above.

As shown, grounding interface **902** includes a conductive body **930** having a ball end **931**, designed to engage with a suitably sized ball socket clamp, such as ball socket clamp **800** described above. As shown in FIG. 9A, conductive body **930** of grounding interface **902** may include a threaded portion **932** configured to engage grounding interface/insulated cap securing portion **926** of multi-function bore **922**. Grounding interface **902** may also include a tool engaging portion **934** configured to enable grounding interface **902** to be secured to grounding device **900** using a wrench or hexagonal socket.

In some embodiments, conductive core **930**, ball end **931**, and tool engaging portion **934** may be formed as one element of conductive material, such as copper, brass, steel, or aluminum. In other implementations, one or more of these components may be formed separately and secured to conductive core **930**, such as via welding, etc.

During assembly, as shown in FIG. 9B, threaded portion **932** of conductive body of grounding interface **902** may be inserted into multi-function bore **922**. Threaded portion **932** then engages threaded portion **928** in multi-function bore **922**. A socket, such as socket **936** shown in FIG. 9B may be used to apply torque to tool engaging portion **934** to secure grounding interface **902** to grounding device **900**.

As shown in FIG. 9C, during connection of ball socket clamp **800** to grounding interface **902**, socket portion **808** is placed over exposed ball end **931** of grounding interface **902**. Tool engaging portion **814** of clamping member **804** is then rotated, e.g., using a lineman's hook, causing the ball engaging portion to travel toward socket portion **808**, thus securing ball end **931** of grounding interface **902** within ball socket clamp **800**.

When it is no longer necessary to ground connector **100**, grounding interface **902** may be removed (e.g., using socket **936**) and a suitable insulating cap may be installed over

second tapered portion **912** and secured via multi-function bore **922** in a manner similar to that described above in relation to FIGS. 1A, 1B, and 2.

Although the embodiment of FIGS. 9A-9C is shown with respect to a reducing plug for inserting into a T-end of a power cable elbow connector, in other embodiments, the configuration of grounding interface **902** may be applied to other devices, such as cam-op link devices, similar to those described above in relation to FIGS. 6-8C.

FIGS. 10A-10C are cross sectional/side view illustrations of yet another exemplary grounding device consistent with embodiments described herein. In particular, FIG. 10A is a cross-sectional diagram illustrating an exemplary grounding device **100** and grounding interface **1002** in a pre-assembled configuration. FIG. 10B is a side view of grounding device **1000** and grounding interface **1002** in an assembled configuration and further illustrating (in cross-section) an exemplary insulating cap **1003** positioned for assembly on grounding device **1000**. FIG. 10C is a side view of grounding device **1000** and grounding interface **1002** showing insulating cap **1003** installed on grounding interface **1000**.

Consistent with embodiments described herein, grounding device **1000**, similar to grounding device **900** described above in relation to FIGS. 9A-9C, includes a conductive core portion **1004** and an insulated body **1006**. In one implementation, insulated body **1006** includes a first tapered portion **1008**, a central portion **1010**, and a second tapered portion **1012**.

Central portion **1010** includes a generally cylindrical configuration having a larger diameter than an interior end of first tapered portion **1006**. During assembly, central portion **1010** abuts an outer surface of second T-end **110** in power cable elbow connector **100**.

Second tapered portion **1012** projects from central portion **1010** in an axial direction away from first tapered portion **1008** and includes a tapered configuration for receiving insulated cap **1003**, as described in additional detail below.

Insulated body **1006** may be formed of an insulative rubber or epoxy material. Furthermore, in some embodiments, central portion **1010** includes an outer shield portion **1014** formed on a radial periphery thereof. Outer shield portion **1014** may be formed of a conductive or semi-conductive material, such as EPDM.

Conductive core **1004** includes a substantially cylindrical configuration that extends through an interior of insulated body **1006**. Conductive core **1004** includes a stud receiving end **1016** and a grounding interface receiving end **1018**. Conductive core **1004** may be formed of a conductive material, such as brass, steel, or aluminum and, upon assembly, may conductively couple with power cable **106** and bushing **112** in power cable elbow connector **100** following installation.

In one embodiment, stud receiving end **1016** includes a threaded opening **1020** for matingly engaging corresponding threads on a bushing, such as bushing **111** described above. However, in other embodiments, other means for coupling with the bushing may be incorporated, such as a push or snap-on connection, etc.

As shown in FIG. 10A, grounding interface receiving end **1018** includes a multi-function bore **1022** formed axially therein. Multi-function bore **1022** extends axially within grounding interface receiving end **1018** and includes a grounding device attachment portion **1024** and grounding interface securing portion **1026**. Grounding device attachment portion **1024** of multi-function bore **1022** may be formed on the interior of multi-function bore **1022** and includes a tool engaging configuration for receiving a tool, such as a hex wrench, therein.

11

During assembly of grounding device **1000** to elbow connector **100**, first tapered portion **1008** of grounding device **1000** is inserted into bore **116** in second T-end **110** of connector **100**. Threaded opening **1020** in stud receiving end **1016** in conductive core **1004** may be threaded onto stud portion **122** of bushing **111**. A suitable tool is then inserted into multi-function bore **1022** and into engagement with grounding device attachment portion **1024**. The tool is then rotated to secure grounding device **1000** within second T-end **110**.

As shown in FIG. **10A**, grounding interface securing portion **1026** of multi-function bore **1022** may include an internally threaded portion **1028** for use in securely retaining grounding interface **1002**, as described below.

Consistent with embodiments described herein, grounding interface **1002** includes a conductive body **1030** having a ball end **1031**, designed to engage with a suitably sized ball socket clamp, such as ball socket clamp **800** described above. As shown in FIG. **10A**, conductive body **1030** of grounding interface **1002** includes first a threaded portion **1032** configured to engage grounding interface securing portion **1026** of multi-function bore **1022**. Grounding interface **1002** may also include a second threaded portion **1033** configured to engage an interior portion of cap **1003**, as described below, and a tool engaging portion **1034** configured to enable grounding interface **1002** to be secured to grounding device **1000** using a wrench or hexagonal socket. As shown in FIG. **10A**, second threaded portion **1033** is positioned below tool engaging portion **1034** (relative to ball end **1031**) and includes an outside diameter greater than an outside diameter of tool engaging portion **1034**.

In some embodiments, conductive core **1030**, ball end **1031**, second threaded portion **1033**, and tool engaging portion **1034** may be formed as one element of conductive material, such as copper, brass, steel, or aluminum. In other implementations, one or more of these components may be formed separately and secured to conductive core **1030**, such as via welding, etc.

During assembly, as shown in FIG. **10B**, first threaded portion **1032** of conductive body of grounding interface **1002** may be inserted into multi-function bore **1022** to engage threaded portion **1028** in multi-function bore **1022**. A socket or wrench may be used to apply torque to tool engaging portion **1034** to secure grounding interface **1002** to grounding device **1000**.

When it is no longer necessary to ground connector **100**, insulating cap **1003** is installed over grounding interface **1002** and second tapered portion **1012** and secured via second threaded portion **1033** in grounding interface **1002**.

In one embodiment, insulated cap **1003** includes an outer conductive or semi-conductive shield **1036**, an insulative inner housing **1038**, typically molded from an insulative rubber or epoxy material, a conductive or semi-conductive insert **1040**, and an engagement portion **1042**. Conductive or semi-conductive insert **1040** is configured to surround ball end **1031** of grounding interface **1002** when insulated cap **1003** is installed on grounding device **1000**.

As shown in FIGS. **10B** and **10C**, insulated cap **1003** includes a substantially conical cavity **1044** formed therein for receiving ball end **1031** and second tapered portion **1012** of grounding device **1000**. The conical configuration of cavity **1044** generally corresponds to the tapered configuration of second tapered portion **1012** to allow insulated cap **1003** to become seated on grounding device **1000** during installation.

As shown in FIGS. **10B** and **10C**, engagement portion **1042** may include internal threads **1046** for engaging the second threaded portion **1033** of grounding interface **1002**. In one

12

implementation, engagement portion **1042** may be formed of a rigid material (e.g., plastic or metal) and may be press-fit into a recess formed into insert **1040**. In other embodiments, engagement portion **1042** may be secured to insert **1040** for other means, such as an adhesive, etc. During assembly, as shown in FIG. **10C**, the threads **1046** of engagement portion **1042** of insulated cap **1003** may be threaded into second threaded portion **1033** and tightened (e.g., by hand) to secure insulated cap **1003** to grounding device **1000**.

Although not shown in FIGS. **10A-10C**, in some embodiments insulated cap **1003** may include a voltage detection test point assembly, a test point cap, and/or a bailing assembly similar to those described above with respect to FIGS. **1A-2**.

It should be noted that, although FIGS. **10A-10C** depict grounding device **1000** and grounding interface **1002** as two separate elements, in other implementations consistent with embodiments described herein, these elements may be combined, such that grounding interface **1002** is formed integral with conductive core **1004**. In such an implementation, grounding device **1000** may be installed into power cable elbow connector using a socket on tool engaging portion **1034**.

The foregoing description of exemplary implementations provides illustration and description, but is not intended to be exhaustive or to limit the embodiments described herein to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the embodiments. For example, although grounding interfaces **658**, **902**, and **1002** have been illustrated and described in terms of ball ends **665**, **931**, and **1031**, and grounding device **113** of elbow connector **100** has been illustrated and described in terms of a cylindrical, clamp engaging end **140**, in other embodiments difference configurations may be implemented in a manner consistent with the described features. For example, grounding device **113** may be provided with a ball end interface and grounding cam-op link assembly **650** may be provided with a cylindrical clamp engaging end. In still other embodiments, different configurations of clamp engaging surfaces may be implemented.

Implementations may also be used for other devices, such as other high voltage switchgear equipment, such as any 15 kV, 25 kV, or 35 kV equipment. For example, various features have been mainly described above with respect to elbow power connectors. In other implementations, other medium/high voltage power components may be configured to include the grounding assemblies described herein.

Although the invention has been described in detail above, it is expressly understood that it will be apparent to persons skilled in the relevant art that the invention may be modified without departing from the spirit of the invention. Various changes of form, design, or arrangement may be made to the invention without departing from the spirit and scope of the invention. Therefore, the above-mentioned description is to be considered exemplary, rather than limiting, and the true scope of the invention is that defined in the following claims.

No element, act, or instruction used in the description of the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. An electrical connector assembly, comprising:
 - a connector body comprising:
 - a conductor receiving end;

13

a first connector end formed substantially perpendicu-
larly to an axial direction of the conductor receiving
end,
wherein the first connector end includes a first axial bore
configured to receive a bushing element therein;
a second connector end formed substantially perpen-
dicularly to the axial direction of the conductor
receiving end and opposing the first connector end,
wherein the second connector end includes a second
axial bore formed therein; and
a grounding element having an insulated body and a con-
ductive core portion extending therethrough,
wherein the grounding element is configured for insertion
into the second axial bore of the second connector end,
wherein the conductive core portion includes an exposed
portion projecting above a surface of the insulated body,
wherein the exposed portion of the grounding element is
configured for attachment by a grounded hot line clamp
to ground the electrical connector assembly, and
wherein the exposed portion of the conductive core com-
prises a generally cylindrical configuration for engaging
clamping members of the hot line clamp.

2. The electrical connector assembly of claim 1, wherein
the second axial bore in the second connector end includes a
tapered configuration, and
wherein a first end of the insulated body of the grounding
element includes a correspondingly tapered configura-
tion for engaging the tapered configuration of the second
axial bore.

3. The electrical connector assembly of claim 2, wherein
the exposed portion of the conductive core projects from a
surface of a second end of the insulated body,
wherein the second end of the insulated body includes a
tapered configuration.

4. The electrical connector assembly of claim 1, wherein
the exposed portion comprises a multi-function bore formed
axially therein,
wherein the multi-function bore includes a first grounding
element attachment portion and a second securing por-
tion separate from the grounding element attachment
portion, and
wherein, following insertion of the grounding element into
the second bore of the second connector end, the ground-
ing element is secured within the second bore by appli-
cation of a tool within the first grounding element attach-
ment portion of the multi-function bore.

5. The electrical connector assembly of claim 4, further
comprising:
an insulated cap configured to cover the exposed portion of
the grounding element when the electrical connector is
in a non-grounded configuration.

6. The electrical connector assembly of claim 5, wherein
the insulated cap comprises an insulated body and a securing
element,
wherein the insulated body of the insulated cap comprises
a tapered cavity therein for receiving the second end of
the insulated body of the grounding element,
wherein the securing element of the insulated cap projects
within the tapered cavity,
wherein the multi-function bore includes a second cap-
securing portion, and
wherein, upon placement of the tapered cavity of the insu-
lated cap on the tapered second end of the insulated body
of the grounding element, the securing element is con-
figured to engage the cap-securing portion of the multi-
function bore.

14

7. The electrical connector assembly of claim 6, wherein
the securing element comprises a threaded stud and wherein
the cap-securing portion of the multi-function bore comprises
a correspondingly threaded portion of the multi-function
bore.

8. The electrical connector assembly of claim 1, wherein
the exposed portion of the conductive core comprises a ball
configuration for engaging a ball socket in the hot line clamp.

9. The electrical connector assembly of claim 1, wherein
the first end of the insulated body of the grounding element
includes a threaded aperture formed axially therein for engag-
ing a threaded stud projecting from the bushing element
received in the first axial bore of the first connector end.

10. The electrical connector assembly of claim 1, wherein
the connector body further comprises:
a link interface opening formed substantially perpendicu-
larly to the axial direction of the conductor receiving end
substantially parallel to the second connector end,
wherein the link interface opening includes a third axial
bore formed therein.

11. The electrical connector assembly of claim 10, wherein
the grounding element comprises:
a grounding cam-op link assembly, comprising:
a link body portion;
a rearward link interface that projects from the link body
to engage the third axial bore in the link interface
opening,
wherein the rearward link interface comprises a bus for
conductively coupling to a power cable in the connec-
tor body;
a forward link interface that projects from the link body
to engage the second axial bore in the second connec-
tor end,
wherein the forward link interface comprises a conduc-
tive core for conductively coupling to the bushing
element in the first axial bore of the first connector
end; and
a grounding interface that projects from the link body
portion,
wherein the grounding interface is conductively coupled
to the conductive core of the forward link interface.

12. The electrical connector assembly of claim 11,
wherein the grounding cam-op link comprises an insula-
tive material formed between the rearward link interface
and the forward link interface to electrically isolate the
bus in the rearward link interface from the conductive
core of the forward link interface.

13. The electrical connector assembly of claim 11, wherein
the grounding interface of the grounding cam-op link assem-
bly comprises a generally cylindrical configuration for
engaging clamping members of the hot line clamp.

14. The electrical connector assembly of claim 11, wherein
the grounding interface of the grounding cam-op link assem-
bly comprises a ball configuration for engaging a ball socket
in the hot line clamp.

15. A medium or high voltage power cable elbow connec-
tor assembly, comprising:
a connector body having a conductor receiving end, a bush-
ing receiving end projecting substantially perpendicu-
larly from the connector body, and a connection end
projecting substantially perpendicularly from the con-
nector body and oriented substantially opposite to the
bushing receiving end,
wherein the connector body includes a first axial bore that
communicates with each of a second axial bore and a
third axial bore in the bushing receiving and connection
ends, respectively, and

15

wherein the bushing receiving end is configured to receive a switchgear bushing therein;

a grounding device configured for insertion into the third axial bore of the connection end,

wherein the grounding device is configured to conductively connect to the switchgear bushing,

wherein the grounding devices include an exposed conductive portion configured to engage a grounded hot line clamp, during grounding of the electrical connector assembly,

wherein the exposed conductive portion of the grounding device comprises one of a cylindrical configuration for engaging clamping members of the hot line clamp or a ball configuration for engaging a ball socket of the hot line clamp; and

an insulated cap configured to cover the exposed conductive portion of the grounding device during normal operation of the electrical connector.

16. A method, comprising:

connecting a bushing interface of the power cable elbow connector to a switchgear bushing,

wherein the power cable elbow connector further comprises a connector body for receiving a power cable therein, and a connector end projecting from the connector body oppositely from the bushing interface,

wherein the connector end includes an axial bore therein; inserting a grounding device into the axial bore in the connector end,

16

wherein the grounding device includes an insulated body and a conductive core extending therethrough,

wherein the conductive core is configured to couple with the bushing in the bushing interface and further includes an exposed conductive portion projecting from the insulated body,

wherein the exposed conductive portion includes a generally cylindrical configuration for engaging clamping members of a hot line clamp during;

installing an insulated cap over the exposed conductive portion of the grounding device;

energizing the power cable elbow connector;

de-energizing the power cable elbow connector;

removing the insulated cap; and

attaching the hot line clamp to the exposed conductive portion of the grounding device,

wherein the hot line clamp is coupled to a ground line to ground the power cable elbow connector.

17. The method of claim **16**, wherein the insulated cap further comprises a voltage test point, the method further comprising:

testing a voltage of the power cable electrical connector via the voltage test point in the insulated cap to determine whether the power cable elbow connector has been de-energized; and

removing the insulated cap when it is determined that the power cable elbow connector has been de-energized.

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